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REPORT NO ________

Limited Effectiveness of Heat Acclimation to Soldiers Wearing U.S. Army and U.S. Air Force Chemical Protective Clothing

U S ARMY RESEARCH INSTITUTE
OF
ENVIRONMENTAL MEDICINE

Natick, Massachusetts

November 1995

19960206 030

UNITED STATES ARMY
MEDICAL RESEARCH AND MATERIEL COMMAND

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	November 1995	Technical Report

4. TITLE AND SUBTITLE
Limited Effectiveness of Heat Acclimation to Soldiers Wearing U.S. Army and U.S. Air Force Chemical Protective Clothing

5. FUNDING NUMBERS

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
US Army Research Institute of Environmental Medicine
Natick, MA 01760-5007

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Same as 7.

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)
Heat acclimation-induced sweating responses have the potential of reducing heat strain for soldiers wearing chemical protective garment. However, this potential benefit is strongly affected by the properties of the garment. If the clothing ensemble permits sufficient evaporative heat dissipation, then heat acclimation becomes helpful in reducing heat strain. On the other hand, if the garment creates an impenetrable barrier to moisture, no benefit can be gained from heat acclimation as the additional sweating cannot be evaporated. We studied 10 subjects exercising on a treadmill while wearing two different U.S. military chemical protective ensembles. Skin heat flux, skin temperature, core temperature, metabolic heat production, and heart rate were measured. We found that the benefit of heat acclimation is strongly dependent on an unimpeded ability of evaporative heat loss from skin areas. The evaporative potential (EP), a measure of thermal insulation modified by moisture permeability, of the clothing ensemble offers a quantitative index useful to determine whether heat acclimation is helpful while wearing protective clothing system. Our data show that when EP is less than 15%, heat acclimation affords no benefit. An evaporative potential graph is created to aid in this determination.

14. SUBJECT TERMS
evaporative potential, heat acclimation, protective clothing, clothing insulation, moisture permeability

15. NUMBER OF PAGES
26

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

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ACKNOWLEDGMENT

The authors thank Dr. Stefan H. Constable, U.S. Air Force Armstrong Laboratory, Brooks Air Force Base, TX, for providing the Air Force ground crew chemical protective coveralls.

EXECUTIVE SUMMARY

Heat acclimation-induced sweating responses have the potential of reducing heat strain for soldiers wearing chemical protective garment. However, this potential benefit is strongly affected by the properties of the garment. If the clothing ensemble permits sufficient evaporative heat dissipation, then heat acclimation becomes helpful in reducing heat strain. On the other hand, if the garment creates an impenetrable barrier to moisture, no benefit can be gained from heat acclimation as the additional sweating cannot be evaporated. We studied 10 subjects exercising on a treadmill while wearing two different U.S. military chemical protective ensembles. Skin heat flux, skin temperature, core (rectal) temperature, metabolic heat production, and heart rate were measured. We found that heat acclimation does enhance sweating output. However, the effectiveness of heat acclimation in reducing heat strain is strongly dependent on an unimpeded ability to evaporatively dissipate heat from skin areas. The evaporative potential (EP), a measure of thermal insulation modified by moisture permeability, of the clothing ensemble offers a quantitative index useful to determine whether heat acclimation is helpful while wearing protective clothing system. Our data show that when EP is less than 15%, heat acclimation affords little benefit during heat stress. An evaporative potential graph is created to aid in this determination.

INTRODUCTION

U.S. military chemical protective suits necessarily encapsulate the soldiers in order to protect them from a variety of external threats. While offering protection, the suits also create an inhospitable environment for the soldiers. This protective shell not only adds to the thermal insulation but also, more importantly, impedes the evaporative heat dissipating ability of the body. Since evaporation of sweat is the major avenue by which human body controls its internal heat accumulation while performing physical work, chemical protective suit wearers are subjected to severe and debilitating heat strain when required to maintain a normal work rate [Goldman, 1963; Martin and Goldman, 1972; Henane et al, 1979; Santee and Wenger, 1988; Gonzalez et al, 1992].

This study investigated the effect of enhanced sweating during heat acclimation in a hot environment on the skin surface heat flux of volunteers dressed in U.S. military chemical protective garments. It is known that heat acclimation in a hot–dry environment increases the sweating rate [Gonzalez et al, 1974; Nadel et al, 1974; Roberts et al, 1977]. Apart from the cardiovascular and performance benefits of heat acclimation, this study examined whether such increased sweating is beneficial in the regulation of heat dissipation while wearing chemical protective suits. A positive result could lead to heat acclimation as a preventive procedure to decrease the heat strain susceptibility of U.S. soldiers wearing chemical protective suits. Could the evaporative potential [Martin and Goldman, 1972] of the garment gives us an indication of whether the sweating enhancement by heat acclimation would be helpful?

Two chemical protective suits were used: a U.S. Army chemical protective battledress overgarment (BDO) and a U.S. Air Force ground crew chemical protective coverall. While these two suits offer similar chemical protection, they have very different design, thermal resistance value, and prescribed usage. The Army suit is a two-piece design, to be worn over Army regular issue fatigue uniform. The Air Force (AF) suit is a one-piece coverall designed to be worn directly over underwear, giving a closer fit.

METHODS

STUDY DESIGN

The U.S. Army Doriot Tropic Environmental Chamber was employed to create the environments during the three stages of the study. The conditions of the three stages are listed below:

	Temperature	Relative Humidity	Wind Speed
Pre-acclimation	35°C	50%	1.0 m/s
Heat Acclimation	49°C	20%	1.0 m/s
Post-heat acclimation	35°C	50%	1.0 m/s

Testing Stages

1. Pre-acclimation. The pre-acclimation (Pre) stage measures the subjects' "raw recruit" responses prior to any physiological adaptation to the testing condition. Other than the initial hydration of 500 ml., water was not given during testing.
2. Heat Acclimation. The heat acclimation (HA) stage was designed to increase the subjects' sweating efficiency by acclimatizing them to a hot and dry environment. The length of acclimation was two weeks. During acclimation, the subjects wore only gym shorts and gym shoes for the treadmill exercise. Water intake was allowed *ad libitum.*
3. Post-heat acclimation. The post-heat acclimation (Post) testings were used for comparison with Pre data to study the effect of sweating efficacy. Water was not given other than the initial 500 ml. hydration.

Testing Scenario

The testing session scenario was as follows:

Testing session scenario

1. Hydration - 500 ml. water.
2. Pre-exercise nude weight.
3. Dress and instrumentation.
4. Pre-exercise clothed weight.
5. treadmill walk.

6. Post-exercise clothed weight.
7. Undress.
8. Post-exercise nude weight.

In the pre- and post-acclimation stages, the subjects donned either U.S. Army or AF chemical protective ensemble. The order of testing the ensembles was randomly determined. Nude and clothed weight losses were measured on a Sauter balance accurate to within ±0.001kg.

SUBJECTS

Ten young adult males were recruited from military personnel as volunteer subjects in accordance with U.S. Army Regulation AR 70-25, Use of Volunteers for Research. The volunteers received a verbal briefing on the purpose, procedures and risks of the study, and each signed an informed consent agreement. Each volunteer received a medical clearance from a medical officer prior to participation. The physical characteristics of the subject pool were (means ± SD): height 1.76 ± 0.05 m; weight 76.6 ± 10.4 kg; (Dubois) body surface area 1.92 ± 0.14 m^2. The age of the group was 22.4 ± 4.4 years. Maximum $\dot{V}O_2$ = 4.03 ± 0.51 l/min (from a USARIEM recent database). This same group of volunteer subjects participated in all three phases of the study.

CLOTHING ENSEMBLES

Two chemical protective ensembles were tested. Each ensemble was tested twice in the pre- and post-acclimation stages.

1. The U.S. Army temperate zone Battle Dress Overgarment (BDO) is a two-layer, two-piece garment of coat and trousers. The outer garment shell is a 50/50 nylon/cotton twill, with a durable water-repellent to repel liquid agents. This outer shell is laminated to an inner layer of polyurethane foam liner impregnated with activated carbon. The outer layer pattern is either olive green or four-color woodland camouflage. This BDO is designed to be worn over Army regular issue BDU.

   The U.S. Army temperate zone BDU consists of a coat and trousers. The uniform is loose fitting to allow body ventilation. The material is a 50/50 nylon/cotton twill, weighing 234 g/m^2 (7 oz/yd^2). The exterior print pattern is four-color woodland camouflage.

The MOPP4 configuration employed in this study also entails donning the Army M17A1 chemical protective mask, butyl rubber hood, butyl rubber gloves with cotton liners, and rubber overboots over the U.S. Army regular issue leather combat boots.

2. The U.S. Air Force chemical defense suit is a one-piece coverall of a similar two-layer construction as the Army BDO. The exterior color is tan. The coverall is intended primarily for ground crew usage. During testing, as dictated by Air Force requirement, the coverall was worn directly over cotton underwear, to provide a closer fitting than the Army BDO. The same U.S. Army M17A1 gas masks, protective gloves, and rubber overboots were used for both the Army BDO and the AF coverall testings.

TREADMILL WALK

The treadmill phase was designed as a 60 minute walk for Pre and Post, and 100 minute walk for HA, on a zero-degree incline treadmill. The treadmill speed was set at 1.34 m/s (3 mph). Some Pre and Post exercise bouts were terminated prior to the 60-minute time when the subjects voluntarily ended the walk because they felt unable to continue or when the subjects' body core temperature had reached 39°C. A third procedure whereby the treadmill walk could end early is when the medical monitor removes a subject because of health concern. This third scenario did not occur during the study. A medical officer was available on-site throughout the testing.

INSTRUMENTATION

The instrumentation phase consisted of attaching probes for measuring skin heat fluxes, skin temperature, rectal temperature, and a 3-point electrocardiogram (EKG).

Data Collection

The EKG was monitored continuously on a stand-alone telemetry system (Hewlett-

Packard 78100A, 78101A). The heart rate data were recorded every ten minutes. The body core temperature (rectal temperature, T_{re}) was measured with a vinyl covered thermistor probe (Yellow Springs Instruments 44033) inserted 10 cm past the anal sphincter. A calibrated six-point, forehead, chest, back, upper arm, thigh, and calf, harness was used to monitor skin heat flux / skin temperature (Concept Engineering combination probe FR-025-TH44018) continuously. Data were recorded every 10 seconds using a personal computer based data acquisition system. At the 10 minute and 30 minute marks of the treadmill walk, $\dot{V}O_2$ was measured using the Douglas bag method. The chemical mask was removed for a two minute collection of expired air, while the subjects continued to walk on the treadmill. Afterwards, the subjects were asked to replace the chemical mask. These $\dot{V}O_2$ data gave the metabolic rates at the thermal transient and steady states. For the HA stage, biophysical data were not recorded, only T_{re} and EKG were observed for medical safety monitoring purpose.

STATISTICAL ANALYSIS

Statistical analysis consisted of repeated measures multiple analysis of variance (MANOVA). Tukey's test (significance level at α=0.05) was used as the *post hoc* test for the existence of significant difference between Army and Air Force clothing ensemble data. Unless otherwise noted, all differences presented in this report are statistically significant, $p<0.05$.

RESULTS

THERMAL INSULATION AND EVAPORATIVE POTENTIAL

The thermal insulation in unit of **clo**, (1 clo = 0.155 $m^2 \cdot K \cdot W^{-1}$) and moisture permeability index (i_m, dimensionless) comparison of the Army and AF suits are shown in Table 1 below. The data were obtained from a thermal copper manikin. The ambient air velocity of the testing environment was 1.1 m/s [Gonzalez et al. 1994].

Table 1 Evaporative Potential (i_m / clo) of Army BDO and AF Coverall

	clo	i_m	i_m/ clo
Army BDO	2.11	0.32	0.15
AF Coverall	1.24	0.35	0.28

The ratio of i_m / clo gives an indication of the theoretical evaporative potential (EP) of the clothing material [Martin and Goldman 1972]. EP of the Army BDO is only half that of the AF coverall.

METABOLIC HEAT PRODUCTION

At the 10-minute and 30-minute marks, metabolic rates were measured. The removal of gas mask during gas collection transiently affected the heat flux data and the evaporation pattern. However, the metabolic rate determination was considered important enough to warrant the procedure. The change in heat flux was only temporary, seen as two small upward excursions in the heat flux data of Figures 1 and 2. It is, therefore, reasonable to surmise that the effect on evaporation was also transient. The replacement of the mask quickly restored the evaporation pattern.

Table 2 gives the average metabolic heat production. The 10 minute and 30 minute measurements represent metabolic rates (in W) at the thermal transient and steady states, respectively.

Table 2 Metabolic rates (in W) at the thermal transient and steady states

	Army BDO		AF Coverall	
	10 min	30 min	10 min	30 min
Pre	423	449	396	421
Post	419	435	395	413

Three observations can be made from Table 2:

1) The steady state metabolic rates (at 30–minute mark) were 4%–5% higher than the transient rate (at 10–minute mark).
2) Comparing the two clothing ensembles, the subjects' metabolic rates were 6% higher when wearing Army BDO than when wearing AF coverall. These data are in agreement with that reported by Aoyagi et al. [1994]. They compared nuclear, biological and chemical (NBC) protective garment with standard Canadian combat clothing and found that the NBC ensemble raised metabolism by 13% relative to the combat clothing. The comparison between the two studies is valid because from a thermal insulation point of view, the two ensembles studied by Aoyagi et al. were very similar to the two garments examined here.
3) Heat acclimation did not significantly alter the metabolic heat production in either garment. The differences between the Pre and Post data were not statistically significant. In this case, our results differ with Aoyagi et al. [1994] findings. Aoyagi et al. reported a small heat acclimation-induced metabolic rate reduction (4%–5%) in the less insulative combat clothing.

BODY WEIGHT LOSS

Table 3 shows the nude and clothed body weight losses from sweating. As the terms imply, the clothed and nude weights were measured from the subjects with and without the chemical protective garments, respectively. The weights were taken immediately before and after the treadmill exercise.

Table 3 Nude and Clothed body weight loss

Nude weight loss (kg)	in Army BDO	in AF Coverall
Pre–Acclimation	1.25	1.32
Post–Acclimation	1.48	1.51
	Δ = 18.4%	Δ = 14.4%

Clothed weight loss (kg)	with Army BDO	with AF Coverall	
Pre–Acclimation	0.25	0.51	Δ = 100%
Post–Acclimation	0.24	0.54	Δ = 125%

For the nude weight loss, there was no significant difference between the clothing ensembles. Similar weight losses were found for both uniforms. However, heat acclimation did affect weight loss. In the Army BDO, an 18.4% increase, and in the AF coverall, a 14.4% increase in weight loss were found. These results support the view that heat acclimation enhanced sweating in the test volunteers.

From the clothed weight loss data, heat acclimation did not produce significant difference in the amount of sweating. The Pre and Post data were similar. However, here, type of clothing ensemble did make a difference. Weight losses were much higher in the AF coverall than in the Army BDO. The differences were 100% and 125% as shown in Table 3. This is because the Army BDO was much less vapor permeable and impeded sweat evaporation much more severely than did the AF coverall.

Comparing the nude and clothed weight losses, it is clear that both ensembles impeded evaporative heat loss. When clothed, the weight losses from sweating were only a fraction of the nude weight losses. For the Army BDO, the clothed weight losses were only 16%–20% of the nude weight losses. For the AF coverall, being more vapor permeable, the figures were slightly higher at 35%–40%.

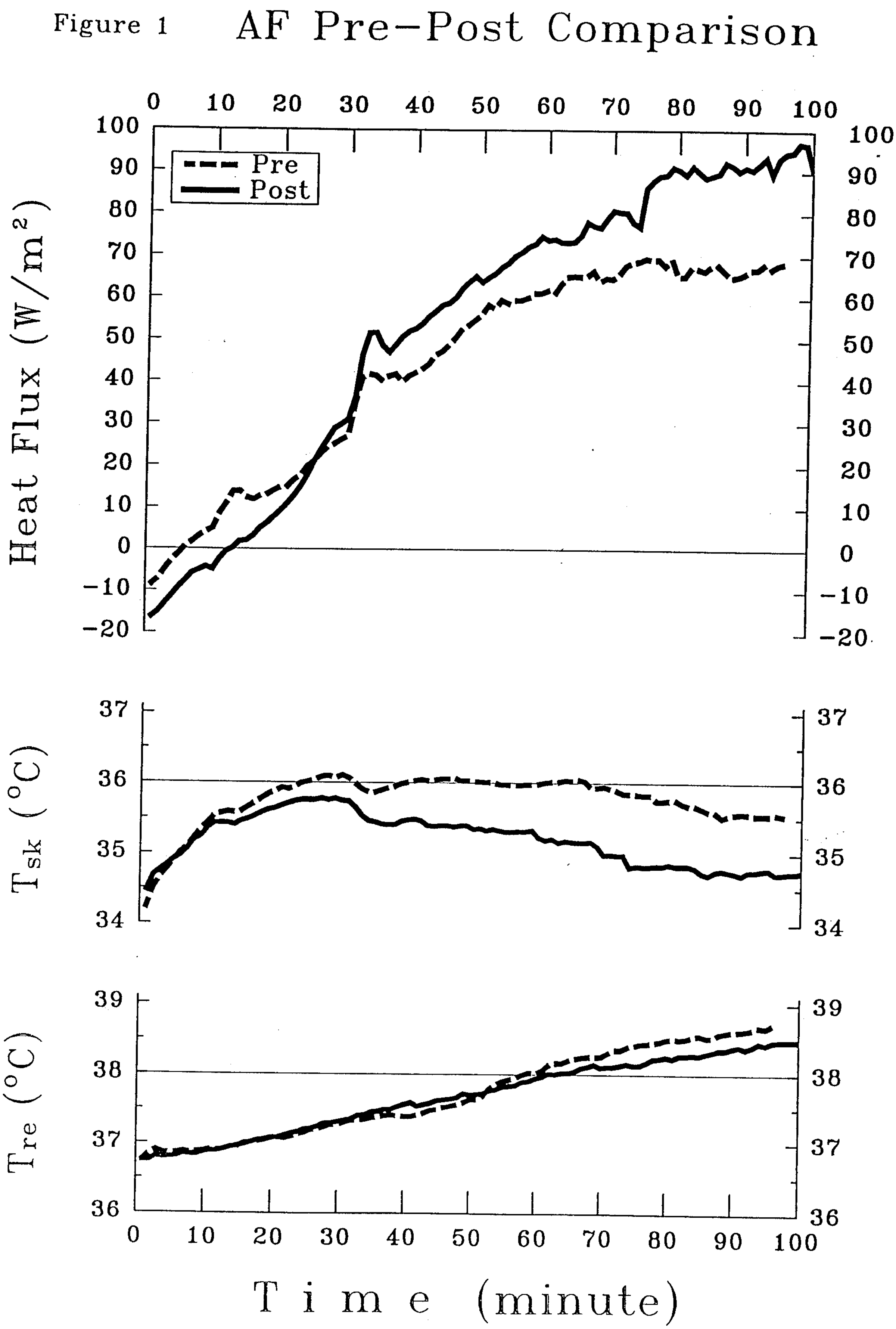
Another observation from Table 3 is that even though heat acclimation does enhance sweating, its sweat evaporation is impeded by the donning of chemical protective garment. The increase in sweating therefore does not help the body's capacity to lose heat. Heat acclimation provides only limited benefit to wearers of impermeable chemical protective suit in reducing heat strain.

HEAT FLUX AND TEMPERATURES

Figures 1 and 2 compare, respectively, the AF and Army Pre–Post data. The weighted average skin heat flux ($\dot{Q}_{HF}$, in $W{\cdot}m^{-2}$), skin temperature ($\bar{T}_{sk}$, in °C) and body core temperature (rectal temperature, T_{re}) of the 10 volunteer subjects are displayed.

Figure 1 shows that heat acclimation increased the skin heat flux. The Post heat loss was 10–20 W/m^2 higher than Pre heat loss. After acclimation, heat dissipation from the skin was enhanced. This response corresponds to that expected from an increase in sweating rate. Theoretically, each skin heat flux transducer measures only dry (nonevaporative) heat transfer. However, in practice, heat flux transducer measures only the difference between its two surfaces. Therefore, if evaporation cools the skin surface, thereby decreases the temperature underneath one transducer surface, this effect of evaporative heat loss will register as skin heat flux. Furthermore, the higher skin heat dissipation was also supported by $\bar{T}_{sk}$. Post $\bar{T}_{sk}$ was lower than Pre $\bar{T}_{sk}$ by 1°C. The differences in Pre and Post core body temperature, T_{re}, were not statistically significant.

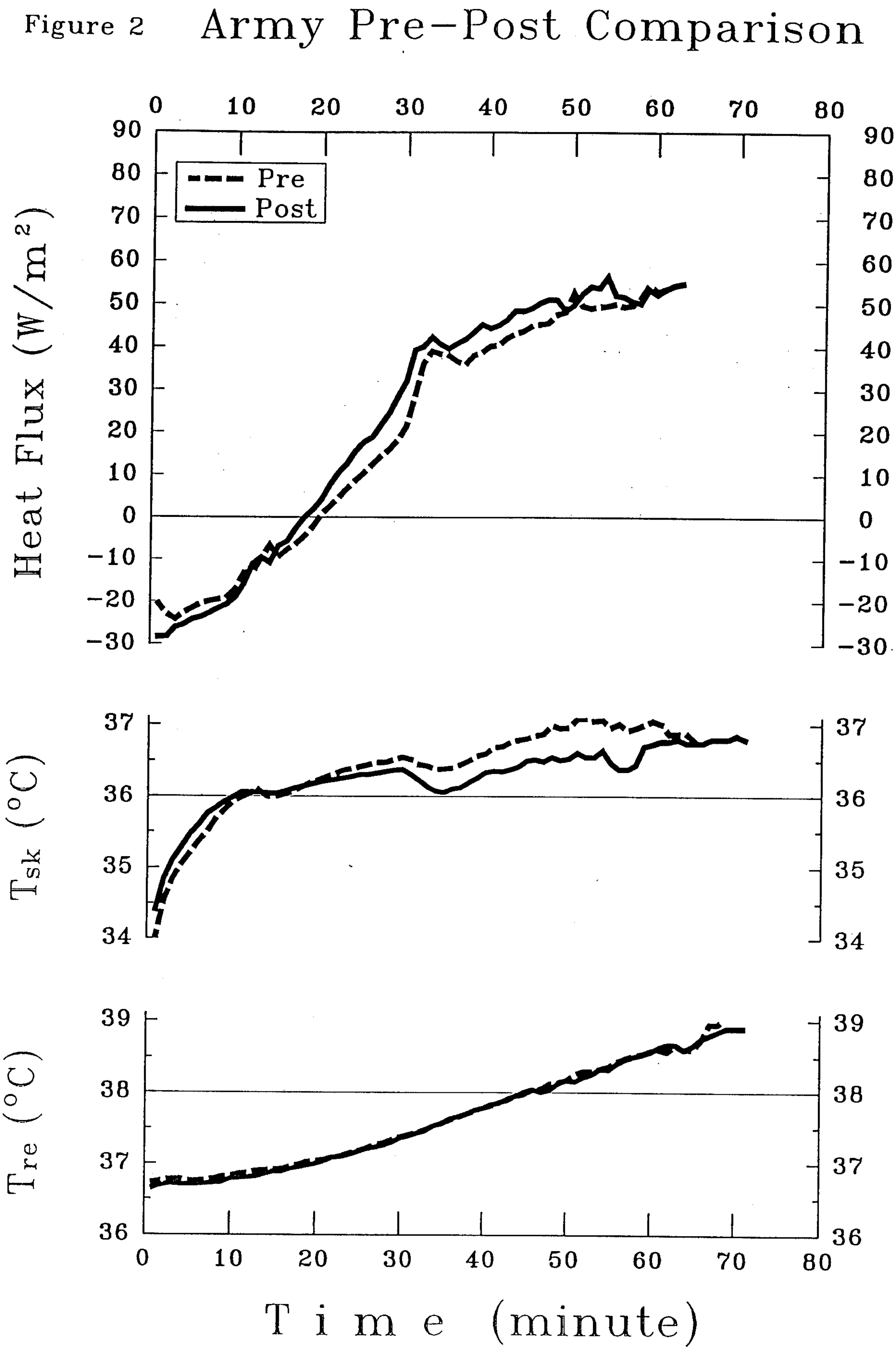
Figure 1



AF Pre-Post Comparison
Pre
Post
Heat Flux (W/m^2)
T_{sk} (°C)
T_{re} (°C)
0 10 20 30 40 50 60 70 80 90 100
100 90 80 70 60 50 40 30 20 10 0 -10 -20
37 36 35 34
39 38 37 36
T i m e (minute)

In Figure 2, for the Army BDO Pre–Post data, all three parameters, $\dot{Q}_{HF}$, $\bar{T}_{sk}$, and T_{re} were not appreciably different between the Pre and Post phases. The results concur with the conclusion drawn earlier: the heat acclimation-induced increase in sweating did not provide any beneficial effect for the wearers of the Army BDO. The additional sweat produced could not be evaporated to aid the body's capacity to lessen its heat load. In contrast, the AF coverall, even though it also impeded heat loss, did permit enough evaporative heat exchange to produce lower $\bar{T}_{sk}$ (shown in Figure 1) and higher clothed weight loss (shown in Table 3).

Figure 2


Army Pre-Post Comparison
Pre
Post
Heat Flux (W/m²)
Tsk (°C)
Tre (°C)
Time (minute)

DISCUSSION

Potential heat loss mechanisms include radiation and convection (R+C) and evaporation. However, the clothing configuration (with mask, hood, rubber gloves and boots) used in this study rendered R+C directly from the skin surface unlikely. Furthermore, comparable skin and ambient temperatures (≈35°C) also precluded convective heat loss. Therefore, heat loss must be, predominately, evaporative in nature. Moreover, because the protective suits encapsulated the wearers, neither uncovered body surface nor clothing (sleeves, collar) openings were accessible, thus evaporation must occur directly from the clothing surface when moisture from sweat penetrated to the outer surface of clothing ensemble. This form of heat loss is quite inefficient. Craig & Moffitt [1974] and Nunneley [1989] reported that evaporative heat loss from the clothing surface offers only minimal cooling effect. Nevertheless, because evaporation must be involved, increased sweating should benefit the rate of heat loss, manifesting in changes in the skin temperature and skin heat flux.

From the AF coverall data in Figure 1, it appears that heat acclimation did increase sweating. The added insulation of the AF coverall hampered evaporative, however, enough heat dissipation apparently did occur to produce an increase in skin $\dot{Q}_{HF}$ and a decrease in $\bar{T}_{sk}$. Presumably, acclimation also increased sweating for the Army BDO, however, $\dot{Q}_{HF}$ and $\bar{T}_{sk}$ did not exhibit the effect of acclimation in Figure 2. If heat acclimation indeed increased the sweating response via the "lowering of the zero point of the central nervous system drive for sweating" [Nadel 1974], then the same threshold offset should have occurred for both the Army BDO and AF coverall. It is not immediately clear why the Army BDO did not exhibit the same effect. There must be other more peripheral or local factors involved than simply a central sweating threshold adjustment.

Gonzalez et al. [1974] suggested a suppression of sweating in highly humid environment. High humidity and excessive wetting of skin surface, actually prevent sweat gland release. Within the highly insulated Army BDO, excessive wetting of the skin surface is highly probable. Sweating could, in fact, be depressed locally by the high skin wettedness. In this scenario, peripheral sweating depression might have counteracted the lowering of central nervous system sweating threshold to result in no change in sweating rate, hence no difference in the skin $\dot{Q}_{HF}$ under the Army BDO.

Heat acclimation has also been reported to decrease the metabolism of exercise [Sawka et al. 1983; Young et al. 1985]. Presumably, lower metabolic rate requires lower peripheral blood flow and sweating to alleviate internal heat buildup. A heat acclimation-induced decrease in the metabolic rate could not be unequivocally observed in this study (Table 2). The data of Roberts et al. [1977] also did not support changes in peripheral blood flow level as a result of heat acclimation. Roberts et al. reported no difference between the pre- and post-acclimation basal skin blood flow (of the forearm). In any case, modified metabolism cannot explain the difference in $\dot{Q}_{HF}$ and $\bar{T}_{sk}$ between Army BDO and AF coverall, because such a metabolic effect must apply equally to both clothing configurations. The intrinsic properties of the clothing ensembles and clothing surface heat transfer must play a part.

The contrasting results of Figures 1 and 2 also suggest the involvement of a clothing factor. If sweating was indeed increased by heat acclimation as implied in Figure 1, yet evaporative heat loss was enhanced only for the AF coverall but not the Army BDO wearers, then the clothing configurations must be responsible for the difference. The obvious differences between the two ensembles were the thermal insulation and moisture permeability, or the EP index.

McLellan et al. [1992] reported that a close fitting NBC garment significantly increased the wearers' work tolerance time. They reasoned that a close fitting suit entailed thinner air layer to absorb and store heat. Thinner air layer also meant lower insulative barrier to latent heat flow, thereby permitted higher rate of evaporative heat dissipation. Following this line of reasoning, if the insulation barrier is high, increased sweating would not enhance evaporative heat loss because the sweat could not be transported through the clothing layers. This was confirmed by Aoyagi et al. [1994] data. Aoyagi et al. reported that when wearing NBC protective clothing, acclimation-induced sweat production was not accompanied by any statistically significant increase in sweat evaporation. As a consequence, heat acclimation did little to reduce the physiological strain imposed by exercising if the subject was wearing NBC protective clothing because the limited vapor permeability of the clothing did not allow evaporative heat loss from the additional sweat that was secreted.

The results shown in this study concur with the above observation. Initially, the high thermal insulation of the Army BDO retained heat generated from exercise to give the initial heat gain. Subsequently, the impenetrable moisture barrier resulted in diminished heat loss in steady state. The low EP (high thermal insulation and low moisture permeability) of the Army BDO prevented or severely limited evaporative heat dissipation resulting in negligible changes in $\dot{Q}_{HF}$ and $\bar{T}_{sk}$ following heat acclimation (Figure 2). On the other hand, the less insulative AF coverall permitted enough evaporative heat loss to take place such that the acclimation-induced sweating enhancement produced the $\dot{Q}_{HF}$ increases and $\bar{T}_{sk}$ decrease, evident in Figure 1.

The above observation combined with knowledge of the thermal insulation and moisture permeability of the clothing ensembles (Table 1) allow the development and construction of an EP graph useful for determining whether heat acclimation could potentially reduce the heat strain experienced by the wearers of particular chemical protective suits. In Figure 3, clothing thermal insulation (in clo) is plotted against the clothing moisture permeability index, i_m. The two straight lines in Figure 3 are <u>equal evaporative potential lines</u>, with the upper line represents EP=0.28 (that of the AF coverall) and the lower line represent EP=0.15 (that of the Army BDO).

The region above the EP=0.28 line is depicted as the "Beneficial Evaporation" zone. When EP≥0.28, an acceptable amount of evaporative heat loss can still take place to provide benefit to the wearers of chemical protective garment. In this zone, heat acclimation could potentially reduce heat strain because acclimation-induced increases in sweating can be evaporated to provide enhanced heat dissipation. The region below the EP=0.15 line is the "Inadequate Evaporation" zone. When EP≤0.15, evaporative heat dissipation is severely hampered. Additional sweating cannot be evaporated. In this zone, heat acclimation would not significantly reduce heat strain experienced by the wearers of chemical protective clothing wearers. The region in between the two equal evaporative potential lines represent zone of 0.15<EP<0.28. The data available from this study cannot offer a definitive resolution of whether heat acclimation could reduce heat strain in this region. Additional research with other clothing ensembles could further refine the determination within this region.

The data of Aoyagi et al. [1994] may be used as a validity check of Figure 3. Aoyagi et al. estimated the properties of their ensembles as follows:

	clo	i_m	i_m/ clo
NBC garment	2.3	0.19	0.08
Combat clothing	1.4	0.44	0.31

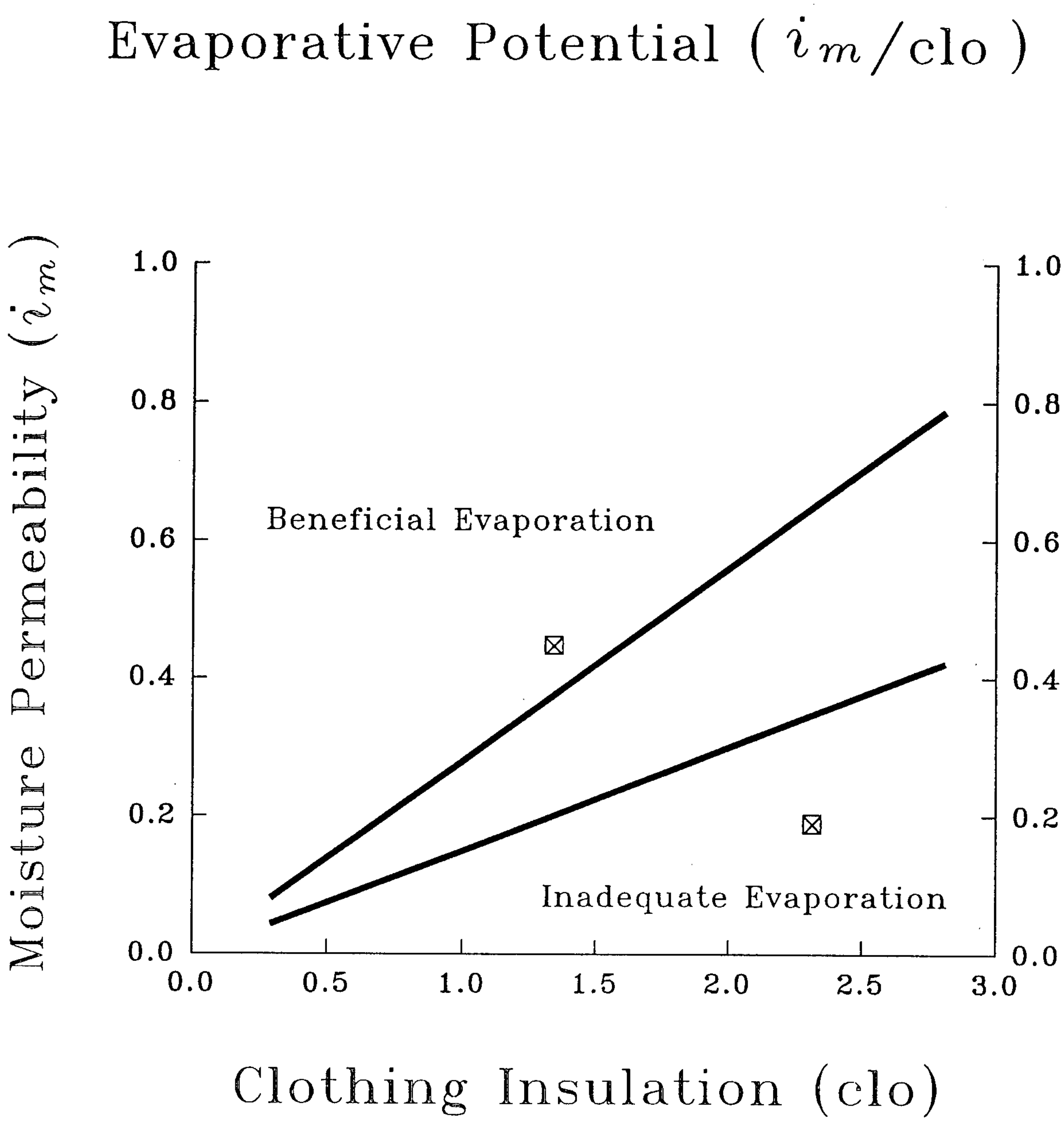
From the EP point of view, the NBC garment and combat clothing are quite similar to the Army BDO and AF coverall, respectively, examined in this study (compare with data in Table 1). The EP of their two clothing ensembles fall in the appropriate regions when plotted on Figure 3 (with symbol ⊠). The combat clothing, allowing acceptable amount of evaporation, is represented by the upper ⊠ in the "Beneficial Evaporation" zone. The lower ⊠ represents the NBC garment with a low EP of 0.08, falls in the "Inadequate

Evaporation" region.

It appears that heat acclimation-induced sweating increases have the potential of reducing heat strain for chemical protective garment wearers, as long as the garment permits sufficient evaporative heat dissipation. The EP, a measure of thermal insulation modified by moisture permeability, of the clothing ensemble is a useful tool with which to judge, *a priori*, whether heat acclimation would be helpful. The EP graph developed in this report can be used to determine whether heat acclimation offers potential heat strain reduction for U.S. soldiers wearing chemical protective clothing.

The EP graph also offers workers in other professions who must also don encapsulating protective clothing, such as fire fighters and chemical spill cleanup crews, a valuable screening tool of potential heat hazards. For these emergency-deployed professionals, a 10-day heat acclimation is often not a possibility and a quick assessment of heat hazard is imperative.

Figure 3



Evaporative Potential (i_m/clo)
Moisture Permeability (i_m)
1.0
0.8
0.6
0.4
0.2
0.0
Beneficial Evaporation
Inadequate Evaporation
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Clothing Insulation (clo)

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